

# **Intel Motes and Sensor Networks**

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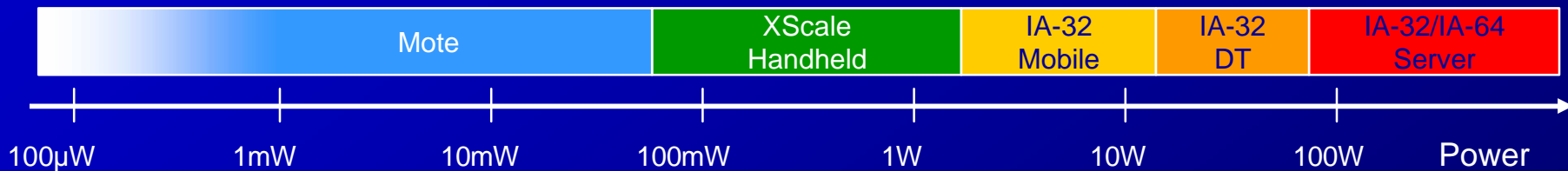
# Outline

- Introduction
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- Intel Mote
- Deployments
- Intel Mote 2
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# Introduction

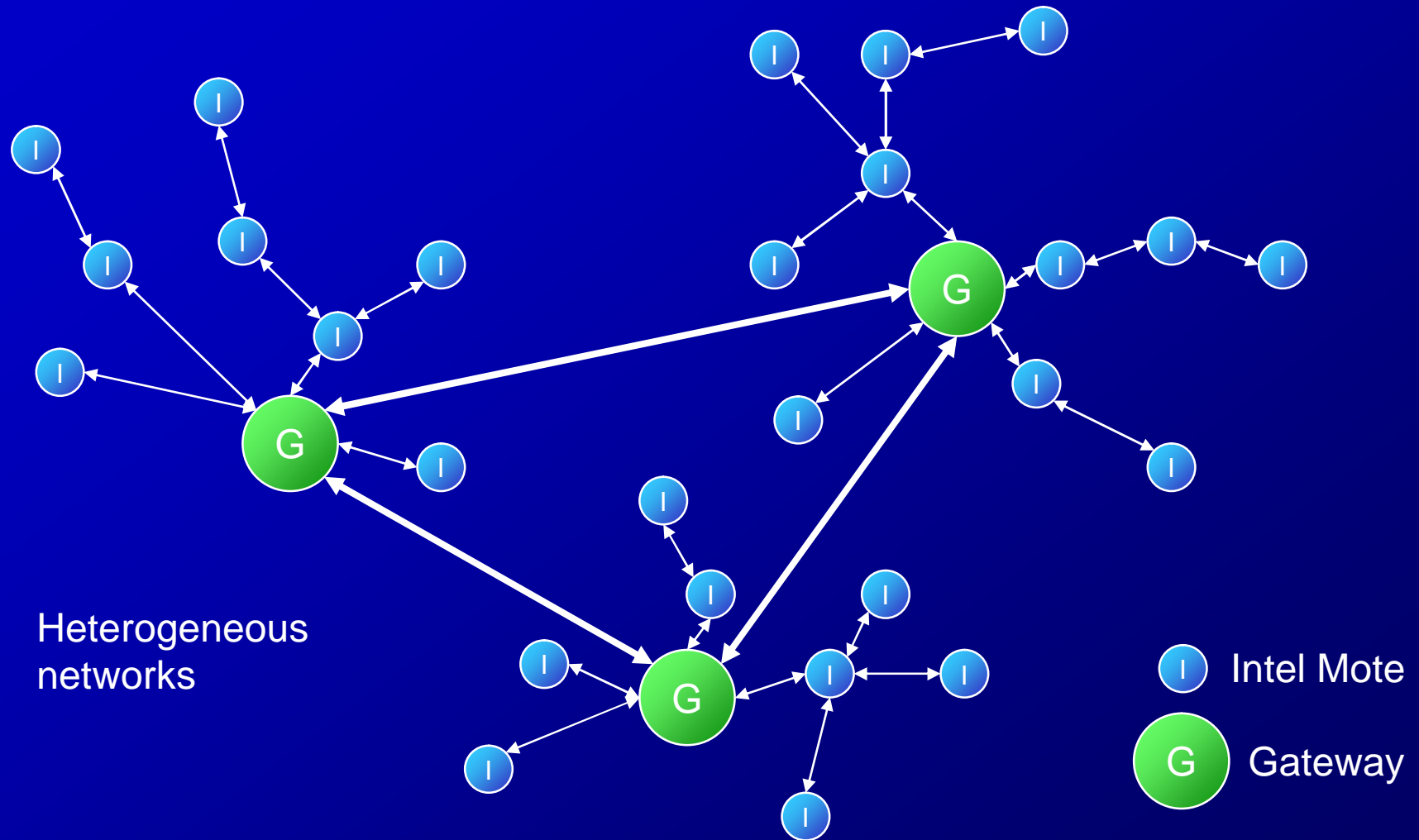
# Motes overview

- A “mote” is a tiny wireless computing platform
  - CPU, memory, FLASH, I/O, radio components
  - Low power operation, often battery operated



- Motes are used to build wireless mesh networks
  - Self configuring and maintaining connectivity
  - Distributed sensing of environmental data
  - Distributed computation capabilities
  - Bandwidth and resources scale with network size

# Self organizing networks



# Motes History

# Early motes

- Early Motes (UCB) focused on low power (Mica, Mica2)
  - 8-bit microcontrollers
  - Small amount of RAM
  - FLASH for persistent data storage
  - Low bandwidth radio
  - Low active power
  - Low sleep power
  - Small physical size



Suitable for low data rate applications  
requiring only minimum data processing

Intel Mote



# Intel Mote

Multicolor  
status LED

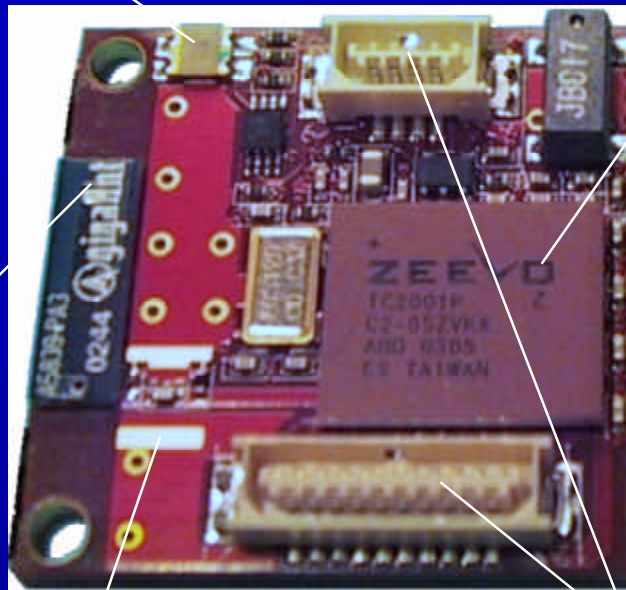
2.4 GHz  
antenna

Optional  
external  
antenna  
connector

Optional  
voltage  
regulator  
(bottom)

ARM\* core  
SRAM  
FLASH  
BT radio

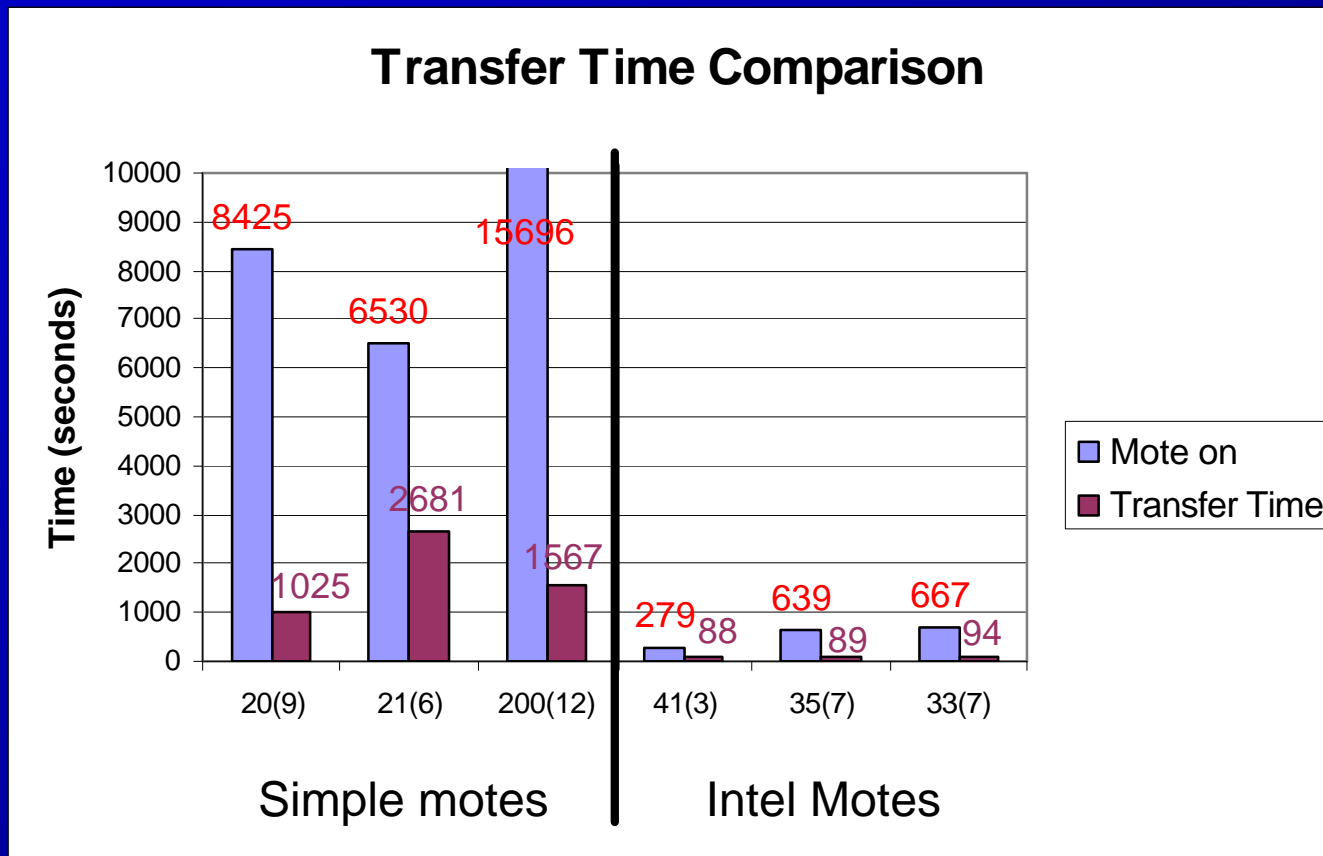
Stackable  
connectors  
(top and  
bottom)



# Learnings from Intel Mote

- Reliable radio significantly improves network performance
  - Reduces total energy consumption of the system
  - Enables higher data collection frequency
  - Spread spectrum resilient to radio interference
- Improved platform features simplify installation and maintenance
  - On-board memory can be used for data storage
  - CPU can be used for data compression
  - Platform manageability features

# Industrial monitoring deployment data transfer time comparison



# Deployments

# Impacts on Key Segments of Society & Economy



**Manufacturing**



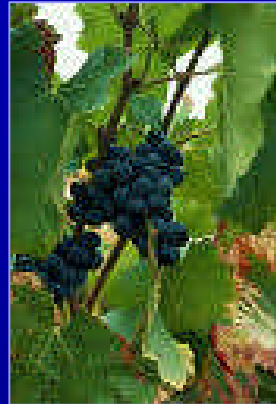
**Distribution**



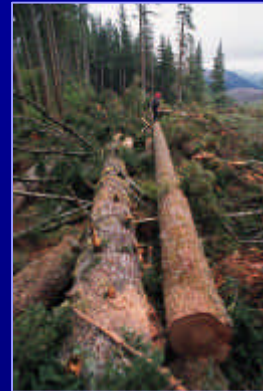
**Retail**



**Construction**



**Agriculture**



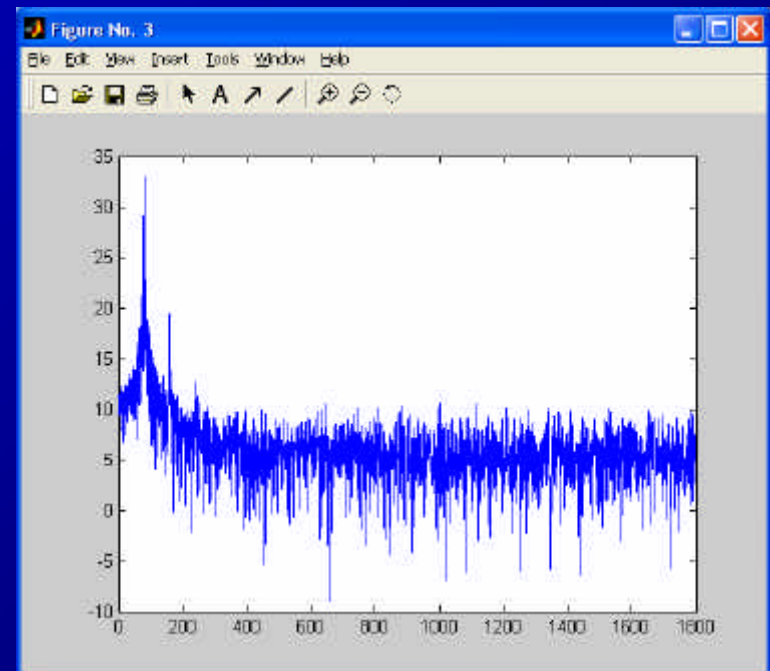
**Environment**



**Health / Life Sciences**

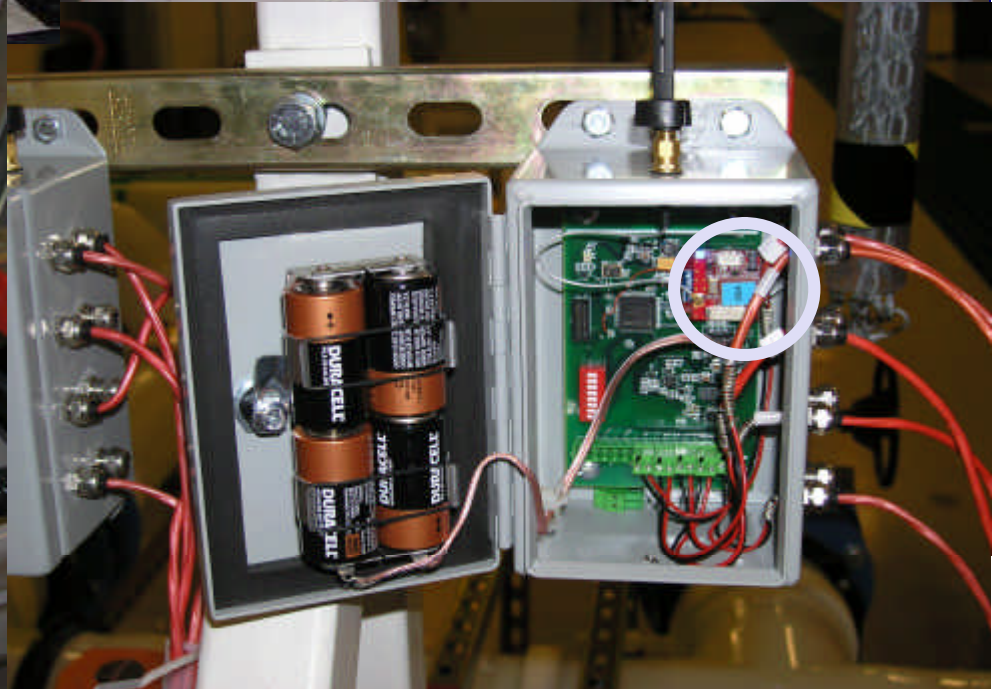
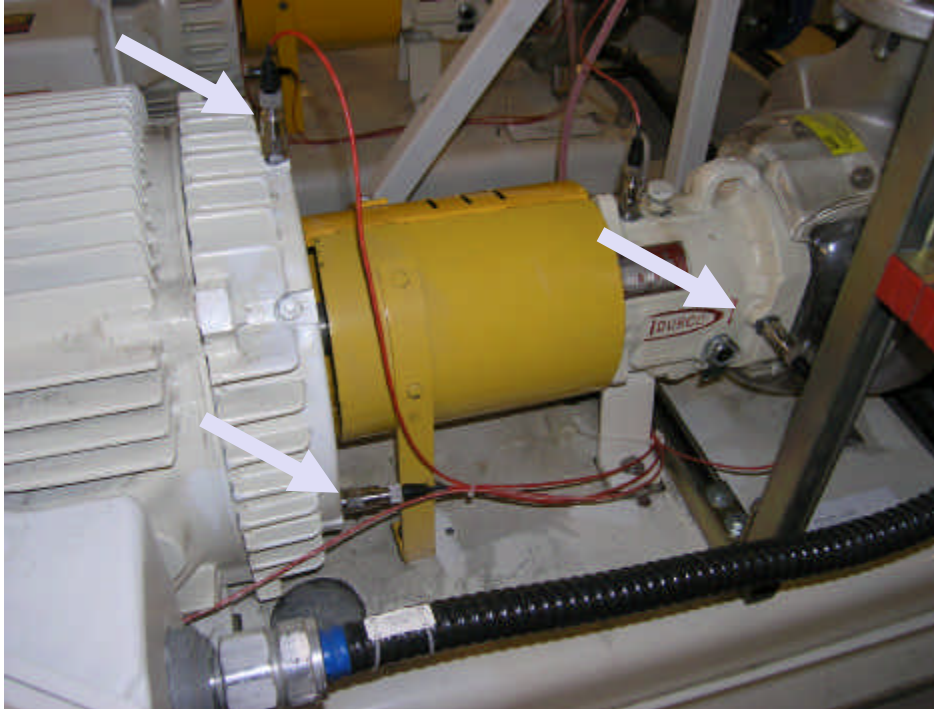
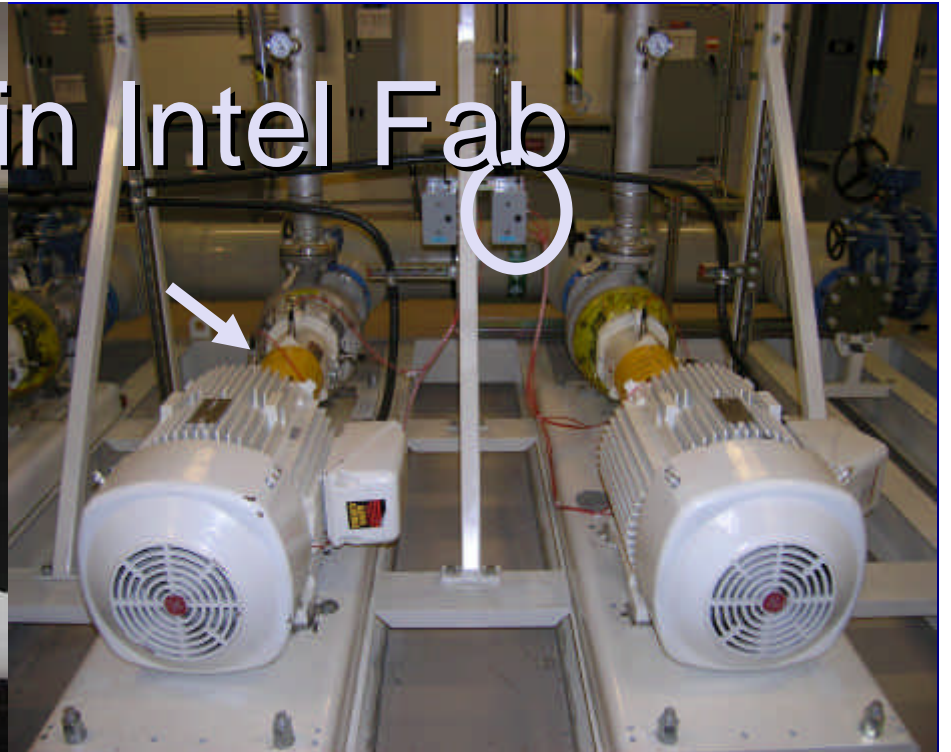
# Condition based Maintenance

- Use vibration signatures to identify problems with equipment
  - Avoid failure during production
- ~4000 Sensors points in each fab
- Done today largely by manual data collection
- Move to wireless sensor network
  - Produce a showcase for sensor and mesh networks
  - Establish application in the industry





# Installation in Intel Fab



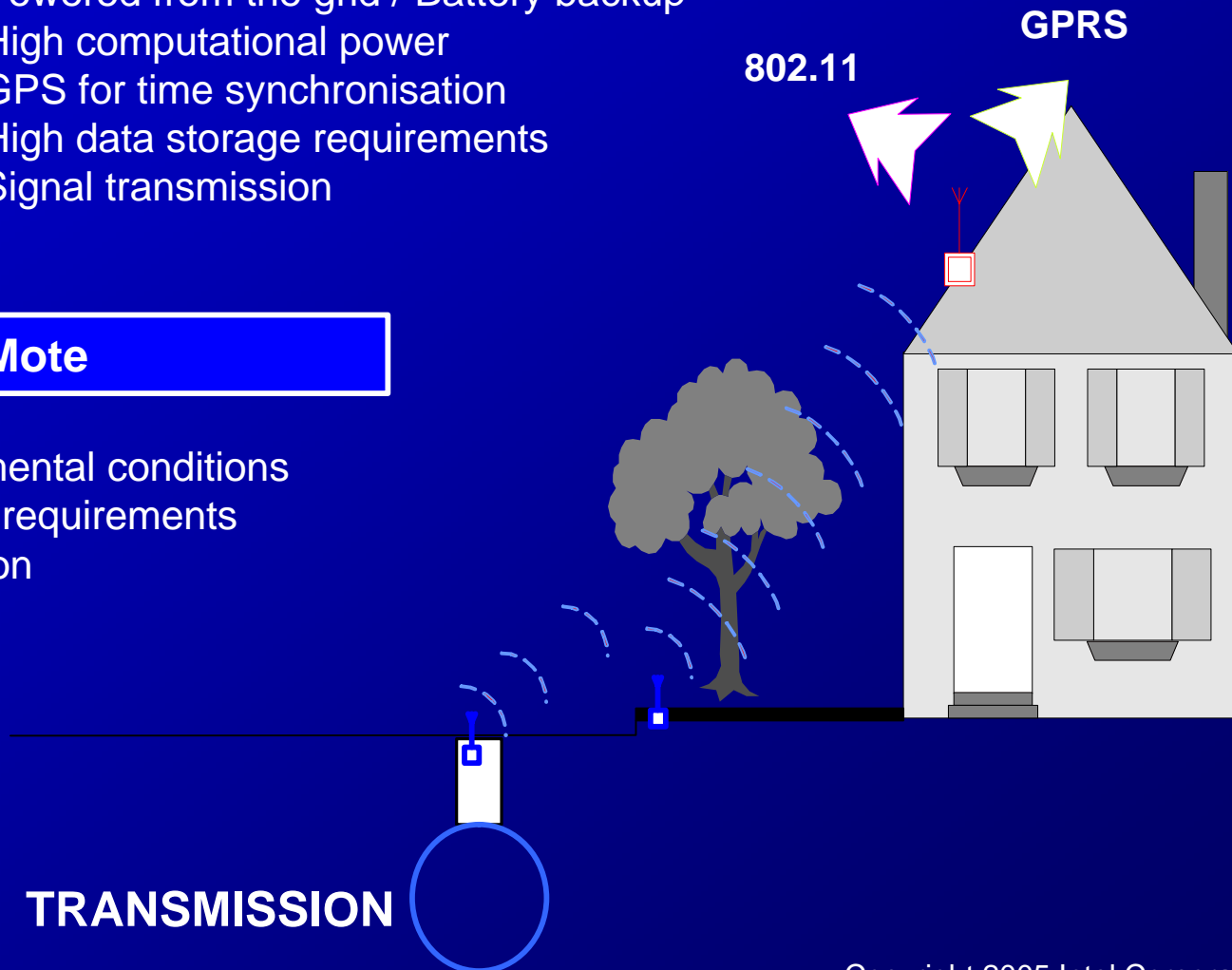
# Water pipeline monitoring

## Gateway

- Powered from the grid / Battery backup
- High computational power
- GPS for time synchronisation
- High data storage requirements
- Signal transmission

## Mote

- Battery operated
- Extreme environmental conditions
- Low data storage requirements
- Signal compression
- Signal encryption





# Installation in Boston

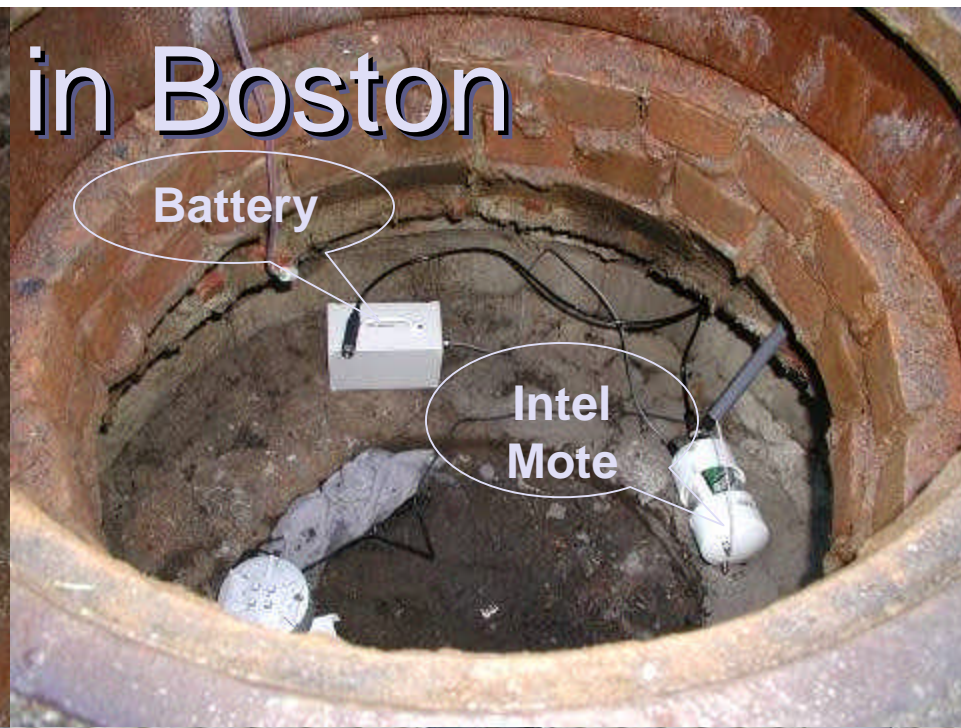
Pressure  
Sensor



Antenna



Battery



Intel  
Mote

Stargate

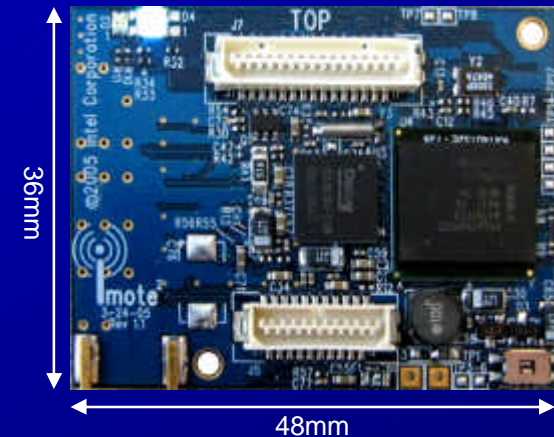


# Intel Mote 2



# Differentiating HW features

- 32bit XScale CPU
  - Scalable performance
  - DSP for data analysis/compression
  - Low power consumption
  - Security coprocessor
- Small physical size



Flexible platform that can be used for a variety of applications  
-> lower overhead in deployment, customization, training

# Differentiating HW features

- Large RAM and FLASH memories
  - Improved network & application performance
  - Data logger capabilities
  - Ability to run Linux OS

Useful in transportation and logistics applications  
(data logger) with sporadic network connectivity

# Differentiating HW features

## ● Variety of I/O options

- Ability to connect various sensors digitally
- High-speed I/O for cameras etc.

## ● Multi-radio support

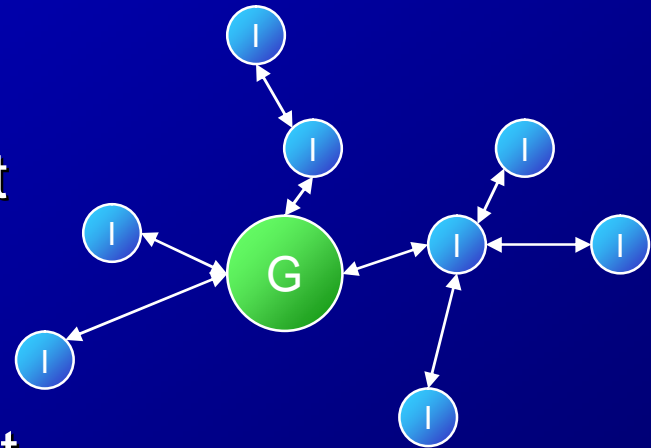
- Enables application driven communication scalability

Ability to connect to a variety of commercial and industrial sensors  
-> lower cost of sensor board attachment

# Differentiating SW features

## ● Reliable networking

- Multi-hop support
- Heterogeneous network support
- Efficient mesh routing
- Self organizing and self-healing
- Integrated network management



Advanced HW and SW capabilities provide a better user experience  
-> lower maintenance cost, increased ROI

# Differentiating SW features

- Support for multiple OS
  - TinyOS, Linux, others
  - JAVA
- Platform and Network wide power management
  - Optimal battery life under real application conditions

Seamlessly integrates with customer IT environment  
Suitable for both AC and battery powered applications

# Summary



# Relevant Intel Products and Research Platforms

- Intel Motes

- ARM and XScale® CPU based advanced Sensor Network nodes

- Intel Gateway “Stargate”

- XScale® CPU based gateway for Sensor Networks

- Sensor Network Software

- TinyOS and Linux based SW infrastructure to support Sensor Network deployments

